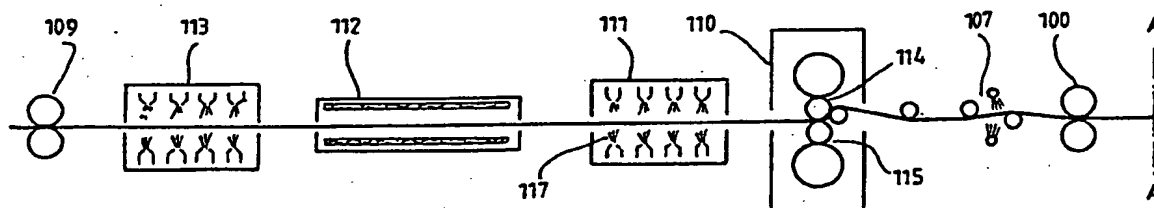




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(54) Title: IN-LINE HEAT TREATMENT OF CONTINUOUSLY CAST STEEL STRIP



## (57) Abstract

Low carbon steel strip (20) cast continuously by a twin roll strip caster comprising casting rolls (16) is treated as it comes from the caster and while it is in line with the caster by a) cooling in a first cooler (111) to a temperature at which austenite in the steel transforms to ferrite and/or other low temperature products, b) reheating in furnace (112) to a temperature not greater than 1200 °C at which ferrite and/or other low temperature phases in the strip are retransformed to austenite, and c) recooling in cooler (113) to retransform austenite in the strip to ferrite. The strip may be passed through reduction rolls (114, 115) to reduce its thickness before it is cooled for the first time.

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- 1 -

## IN-LINE HEAT TREATMENT OF CONTINUOUSLY CAST STEEL STRIP

## TECHNICAL FIELD

This invention relates to cast steel strip produced by continuous casting. It has particular application to the production of steel strip by twin roll casting but may also be applied to production by other continuous casting techniques such as by a single roll caster.

In a twin roll caster molten metal is introduced between a pair of contra-rotated chilled casting rolls so as to form a casting pool of molten metal above the nip between the rolls. Metal shells solidify on the moving roll surfaces and are brought together at the nip between them to produce a solidified strip product at the outlet from the roll nip. The term "nip" is used herein to refer to the general region at which the rolls are closest together. The molten metal may be introduced into the nip between the rolls via a tundish and a metal delivery nozzle located beneath the tundish so as to receive a flow of metal from the tundish and to direct it into the nip between the rolls.

Although twin-roll casting has been applied with some success to non-ferrous metals which solidify rapidly on cooling, there have been problems in applying the technique to the casting of ferrous metals. Some of these problems have been addressed by the inventions disclosed in our previous Patent Specification Nos 631728, 645296, 634896, and 634429. These developments have permitted steel strip to be cast continuously without breakages and without major structural defects. However, because the steel strip exits the caster at high temperatures, typically in excess of 1200°C, it is produced with a very coarse-grained austenitic structure which can on further cooling without refining lead to a strip with poor ductility. Specifically, for low carbon steel below 0.20 wt% carbon the coarse austenitic structure transforms on cooling with a tendency to form acicular ferrite and

- 2 -

bainite.

By the present invention it is possible to modify the metallurgical structure of the steel strip as it is produced by a continuous strip caster so as to produce a final strip product with good ductility and other mechanical properties.

#### DISCLOSURE OF THE INVENTION

According to the invention there is provided a method of producing low carbon steel strip, comprising continuously casting a solidified strip product from a molten casting pool of low carbon steel in a continuous caster and treating the solidified strip as it comes from the caster and while it is in line with the caster by:

(a) cooling the solidified strip to a temperature at which austenite in the steel transforms to ferrite and/or other low temperature phases;

(b) reheating the strip to a temperature not greater than 1200°C at which ferrite and/or other low temperature phases in the strip are retransformed to austenite; and

(c) recooling the strip to retransform austenite in the strip to ferrite.

The strip may be cooled for the first time to a temperature at which the austenite in the steel transforms to ferrite and/or other low temperature phases by cooling to a temperature less than 800°C, and preferably to a temperature less than 700°C. Cooling may be achieved by subjecting the strip to water sprays or gas blasts or by roll cooling.

The method according to the invention may include the step of passing the strip through reduction rolls to reduce the thickness of the strip while it is in line with the caster.

The strip may be passed through the reduction rolls to reduce its thickness before the strip is cooled for the first time to a temperature at which austenite in the steel transforms to ferrite and/or other low temperature phases.

- 3 -

Alternatively, the strip may be passed through the reduction rolls to reduce its thickness before recooling of the strip to retransform austenite in the strip to ferrite.

5 In either case the hot solidified strip may be passed through the reduction rolls while at a temperature in the range 900°C to 1100°C, preferably at a temperature of the order of 1050°C.

10 Passing the strip through the reduction rolls enables improved gauge control and reduction of porosity in the final strip product. Moreover, if the rolling is such as to produce a thickness reduction in the range 20% to 50%, it will cause a refinement of the austenitic grain size in the strip which will significantly increase the  
15 transformation temperature at which austenite will transform to ferrite on cooling. Accordingly, in the case where rolling is carried out prior to cooling for the first time, the lowest temperature to which the strip must be cooled before it is reheated can be substantially raised  
20 with a consequent reduction in the total energy consumed by the process. Specifically, it will be possible with some steels to transform austenite to ferrite at temperatures up to 800°C if the strip is rolled whereas in the absence of rolling the strip may need to be cooled to temperatures in  
25 the range 600°C to 700°C.

The reheating of the strip to retransform ferrite and/or other low temperature phases to austenite preferably raises the temperature of the strip to no more than 1100°C, more preferably to no more than 1100°C, more preferably to  
30 no more than 1050°C.

The reheating of the strip to retransform ferrite and/or other low temperature phases in the strip to austenite preferably raises the temperature of the strip to more than 900°C. More particularly, the strip may be  
35 reheated to a temperature of the order of 950°C.

The reheating of the strip to retransform ferrite and/or other low temperature phases to austenite preferably

- 4 -

raises the temperature of the strip to a temperature below that at which coarse grains of austenite form.

The reheating may be carried out in an induction or other type of furnace.

5           The recooling of the strip to retransform austenite in the strip to ferrite is preferably carried out by accelerated cooling of the strip to a temperature less than 700°C following which the strip may be brought to ambient temperature by forced or natural cooling (in a  
10           coiled condition). The accelerated cooling may be produced by subjecting the strip to water sprays or gas blasts or roll cooling and preferably reduces the strip to a temperature in the order of 650°C.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15           In order that the invention may be more fully explained, one particular embodiment will be described in some detail with reference to the accompanying drawings in which:

20           Figure 1 is a temperature-time history of a steel sample subjected to thermal cycling in a dilatometer;

            Figure 2 is a photomicrograph of the steel specimen subjected to the conditions shown in Figure 1;

25           Figure 3 is a photomicrograph of another steel specimen of the same composition but cooled directly from elevated temperature without thermal cycling;

            Figure 4 is photomicrograph showing the microstructure of a cast steel strip cooled without thermal cycling and coiled at 600°C;

30           Figure 5 is a photomicrograph showing the structure of a cast steel strip of the same composition but subjected to thermal cycling;

            Figures 6A and 6B join on the line A-A to form a side elevation of a continuous strip caster installation constructed to operate in accordance with the invention;

35           Figure 7 is a plan view of part of the continuous strip caster installation shown in Figure 6;

            Figure 8 is a vertical cross-section on the line

- 5 -

8-8 in Figure 7;

Figure 9 is a vertical cross-section on the line 9-9 in Figure 7; and

5 Figure 10 is a vertical cross-section on the line 10-10 in Figure 7.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A series of experiments have been carried out to investigate the microstructures which can be produced in low carbon steel strip by thermal cycling in accordance with the present invention. One series of experiments made use of high temperature dilatometer in which it was possible to apply heating and cooling to steel specimens at accurately controlled rates to simulate conditions achievable in a continuous strip caster. Various steel compositions were investigated and these were subjected to a cooling, reheating and recooling regime. Initially each specimen was heated to a temperature of 1350°C and held for two minutes in the dilatometer before cooling to a temperature below which all austenite had transformed to lower temperature transformation products. The specimens were then reheated to a temperature at which they were completed re-austenitised and were then re-cooled.

Tests were carried out using various cooling and reheating rates for the various grades of steel. These tests showed that the initial cooling and reheating rates are not very critical and that provided the specimen is reheated to a temperature a little above that at which the strip is completely re-austenitised it will produce on final cooling a fine ferrite structure. Figure 1 illustrates the specific conditions applied to a sample of A06 low carbon steel and Figure 2 illustrates the microstructure produced in that specimen. By comparison, Figure 3 illustrates the microstructure obtained when a specimen of A06 steel was cooled directly from a temperature of 1350°C to room temperature without thermal cycling.

The results obtained from the dilatometry

- 6 -

experiments have been confirmed by laboratory strip casting trials involving the production of 2mm thick steel strip on a twin roll caster. Samples of the cast strip were cooled to approximately 650°C before being placed in a fluidised  
5 bed furnace at 950°C for one minute and then cooled in air to room temperature. By comparison, the bulk of the material produced from the cast was cooled with water sprays and coiled at approximately 600°C. Figure 4 is a photomicrograph showing the microstructure of a low carbon  
10 steel strip simply cooled and coiled at 600°C and Figure 5 is a photomicrograph showing the microstructure of steel from the same strip subjected to the reheating and cooling cycle.

Figures 6 to 10 illustrate a complete continuous  
15 strip caster installation constructed to operate in accordance with the invention. This caster comprises a main machine frame 11 which stands up from the factory floor 12. Frame 11 supports a casting roll carriage 13 which is horizontally moveable between an assembly station  
20 14 and a casting station 15. Carriage 13 carries a pair of parallel casting rolls 16 to which molten steel is supplied during a casting operation from a ladle 17 via a tundish 18 and a delivery nozzle 19. Casting rolls 16 are water  
25 cooled so that shells solidify on the moving roll surfaces and are brought together at the nip between them to produce solidified strip product at the roll outlet. In accordance with the present invention this product is fed through a pinch roll 100 and descaler 107 to a reducing roll stand denoted generally as 110 and thereafter successively  
30 through a strip cooler 111, a strip reheat furnace 112, a second strip cooler 113 and further pinch rolls 109.

A receptacle 23 is mounted on the machine frame adjacent the casting station and molten metal can be diverted into this receptacle via an overflow spout 24 on  
35 the tundish or by withdrawal of an emergency plug 25 at one side of the tundish if there is a severe malformation of product or other severe malfunction during a casting



- 7 -

operation.

Roll carriage 13 comprises a carriage frame 31 mounted by wheels 32 on rails 33 extending along part of the main machine frame 11 whereby roll carriage 13 as a whole is mounted for movement along the rails 33. Carriage frame 31 carries a pair of roll cradles 34 in which the rolls 16 are rotatably mounted. Roll cradles 34 are mounted on the carriage frame 31 by interengaging complementary slide members 35, 36 to allow the cradles to be moved on the carriage under the influence of hydraulic cylinder units 37, 38 to adjust the nip between the casting rolls 16. The carriage is movable as a whole along the rails 33 by actuation of a double acting hydraulic piston and cylinder unit 39, connected between a drive bracket 40 on the roll carriage and the main machine frame so as to be actuable to move the roll carriage between the assembly station 14 and casting station 15 and vice versa.

Casting rolls 16 are contra rotated through drive shafts 41 from an electric motor and transmission mounted on carriage frame 31. Rolls 16 have copper peripheral walls formed with a series of longitudinally extending and circumferentially spaced water cooling passages supplied with cooling water through the roll ends from water supply ducts in the roll drive shafts 41 which are connected to water supply hoses 42 through rotary glands 43. The rolls may typically be about 500mm diameter and may be up to several metres long to produce a plurality of strips as described below.

Ladle 17 is of entirely conventional construction and is supported via a yoke 45 on an overhead crane whence it can be brought into position from a hot metal receiving station. The ladle is fitted with a stopper rod 46 actuable by a servo cylinder to allow molten metal to flow from the ladle through an outlet nozzle 47 and refractory shroud 48 into tundish 18.

Tundish 18 is also of conventional construction. It is formed as a wide dish made of a refractory material

- 8 -

such as magnesium oxide (MgO). One side of the tundish receives molten metal from the ladle and is provided with the aforesaid overflow 24 and emergency plug 25. The other side of the tundish is provided with a series of longitudinally spaced metal outlet openings 52. The lower part of the tundish carries mounting brackets 53 for mounting the tundish onto the roll carriage frame 31 and provided with apertures to receive indexing pegs 54 on the carriage frame so as to accurately locate the tundish.

Delivery nozzle 19 is formed as an elongate body made of a refractory material such as alumina graphite. Its lower part is tapered so as to converge inwardly and downwardly so that it can project into the nip between casting rolls 16. It is provided with a mounting bracket 60 whereby to support it on the roll carriage frame and its upper part is formed with outwardly projecting side flanges 55 which locate on the mounting bracket.

Nozzle 19 may have a series of horizontally spaced generally vertically extending flow passages to produce a suitably low velocity discharge of metal throughout the width of the rolls and to deliver the molten metal into the nip between the rolls without direct impingement on the roll surfaces at which initial solidification occurs. Alternatively, the nozzle may have a single continuous slot outlet to deliver a low velocity curtain of molten metal directly into the nip between the rolls and/or it may be immersed in the molten metal pool.

The pool is confined at the ends of the rolls by a pair of side closure plates 56 which are held against stepped ends 57 of the rolls when the roll carriage is at the casting station. Side closure plates 56 are made of a strong refractory material, for example boron nitride, and have scalloped side edges 81 to match the curvature of the stepped ends 57 of the rolls. The side plates can be mounted in plate holders 82 which are movable at the casting station by actuation of a pair of hydraulic cylinder units 83 to bring the side plates into engagement

- 9 -

with the stepped ends of the casting rolls to form end closures for the molten pool of metal formed on the casting rolls during a casting operation.

5 During a casting operation the ladle stopper rod 46 is actuated to allow molten metal to pour from the ladle to the tundish through the metal delivery nozzle whence it flows to the casting rolls.

10 The strip 20 is initially guided to pinch rolls 100 and the reducing roll stand 110 by actuation of an apron table 96. Apron table 96 hangs from pivot mountings 97 on the main frame and can be swung toward the coiler by actuation of an hydraulic cylinder unit 98. Table 96 may operate against an upper strip guide flap 99 actuated by a piston and a cylinder unit 101 and the strips 20 may be  
15 confined between a pair of vertical side rollers 102. After the strip has been guided in to the reducing roll stand 110, the apron table is allowed to swing back to its inoperative position where it simply hangs from the machine frame clear of the product which is taken directly into the  
20 reducing roll stand 110.

Since the hot strip 20 solidifies at temperatures in excess of 1200°C it has a coarse austenitic structure. The austenite grain size may typically be of the order of 500 microns. If this hot strip is simply allowed to cool  
25 to ambient temperatures the coarse grained austenite will tend to transform to form acicular ferrite or bainite and the final strip product will have poor ductility. However, the hot rolling of the strip and thermal cycling to which it is subjected by the cooler 111, furnace 112 and recoiler  
30 113 modifies the metallurgical structure of the strip as it comes off the strip caster so as to produce a final strip product with good ductility and other mechanical properties.

35 The reducing roll stand 110 comprises upper and lower rollers 114, 115. The strip is passed through these rollers at a temperature of the order of 1050°C and the rolls reduce its thickness of the order of 30%. The roll

- 10 -

reduction reduces the porosity of the final strip product and it also enables its thickness to be accurately gauged. Moreover, hot rolling of the strip to produce a reduction of 20-50% at temperatures in excess of 900°C causes the austenite to recrystallise to produce an austenitic structure of significantly less grain size than the strip leaving the casting rolls 16 and this significantly raises the temperature at which the austenite will transform on cooling to ferrite or other low temperature phases. Typically, the strip leaving the reduction roll stand may have an austenitic structure with a grain size of the order of 100 microns compared with the grain size of the order of 500 micron in the strip leaving the caster and this may increase the relevant transformation temperature by as much as 100°C, so reducing the cooling requirement prior to reheating and therefore the total energy consumption for reheating in the process. The roll reduction also reduces porosity of the strip product.

Cooler 111 comprises a series of water sprays 117 which spray water onto the strip to reduce its temperature at the rate of about 20°C to 200°C per second from the reduction roll temperature of 1050°C down to a temperature of about 600°C. This is well below the temperature  $A_c$ , at which austenite in the strip transforms during cooling to ferrite and other low temperature phases. The above described dilatometry testing has shown that with low carbon steel strip of carbon 0.06 wt% coarse grained austenitic structures will commence to transform to ferrite at around 775°C on cooling whereas fine grained austenitic structures will commence transform at around 830°C. Accordingly, in passing through the cooler 111 the austenite in the strip is transformed to ferrite with some pearlite or carbide. The strip then passes through induction furnace 112 which reheats the strip to a temperature of around 950°C. This is above the temperature  $A_c$ , at which the material will be austenitised on heating. The material is thus re-austenitised to produce austenite

- 11 -

with a much smaller grain size than was present prior to the thermal cycling. Specifically, the material leaving furnace 112 will have an austenite grain size of the order of 20 microns.

5           The strip material leaving furnace 112 is rapidly cooled in cooler 113 at a rate of 20°C to 200°C per second down to a temperature of 650°C which is less than the transformation temperature  $A_1$ , for the relatively fine grained austenitic material. This material is therefore  
10 transformed to produce fine grained ferrite, typically with a grain size of the order of 5-10 microns. The strip material may thereafter be passed to a coiler (not shown) and be allowed to cool to ambient temperatures in a coiled condition, although it would be possible to continue the  
15 accelerated cooling down to such temperature.

Because of its fine grained ferritic structure, the final strip product is very ductile and can readily be cold rolled and shaped. Because of the hot rolling step, it also has very low porosity. However, the hot rolling  
20 step may, in some circumstances, be omitted. In this case the hot strip product coming from the casting roll 16 is passed directly to cooler 111 which reduces its temperature down to 600°C as before.

In a further modification to the process, the  
25 roll stand 110 may be located between the furnace 112 and the recoiler 113 so that rolling of the strip to reduce its thickness is carried out after the reheating step and before the recooling step of the thermal recycling process.

- 12 -

**CLAIMS:**

1. A method of producing low carbon steel strip, comprising continuously casting a solidified strip product from a molten casting pool of low carbon steel in a continuous caster and treating the solidified strip as it comes from the caster and while it is in line with the caster by:
  - (a) cooling the solidified strip to a temperature at which austenite in the steel transforms to ferrite and/or other low temperature phases;
  - (b) reheating the strip to a temperature not greater than 1200°C at which ferrite and/or other low temperature phases in the strip are retransformed to austenite; and
  - (c) recooling the strip to retransform austenite in the strip to ferrite.
2. A method as claimed in claim 1, wherein the steel strip is cooled for the first time to a temperature at which the austenite in the steel transforms to ferrite and/or other low temperature phases by cooling to a temperature less than 800°C.
3. A method as claimed in claim 2 wherein the steel strip is cooled for the first time to a temperature at which the austenite in the steel transforms to ferrite and/or other low temperature phases by cooling to a temperature less than 700°C.
4. A method as claimed in any one of claims 1 to 3, which includes the step of passing the strip through reduction rolls to reduce the thickness of the strip while it is in line with the caster.
5. A method as claimed in claim 4, wherein the strip is passed through said reduction rolls while at a temperature in the range 900°C to 1100°C.
6. A method as claimed in claim 4 or claim 5, wherein the strip is passed through said reduction rolls to reduce its thickness before the steel strip is cooled for the first time to a temperature at which austenite in the steel transforms to ferrite and/or other low temperature

- 13 -

phases.

7. A method as claimed in claim 6, wherein the hot strip is reduced in thickness by the rolling step by between 20% and 50% whereby to raise the transformation temperature at which austenite in the steel strip will transform to ferrite and/or other low temperature phases during the initial cooling step.

8. A method as claimed in claim 4 or claim 5, wherein the strip is passed through said reduction rolls to reduce its thickness after the strip has been reheated and before recooling of the strip to retransform austenite to ferrite.

9. A method as claimed in claim 8, wherein the strip is reduced in thickness by the rolling step by between 20% to 50%.

10. A method as claimed in any one of the preceding claims in which the reheating of the strip to a temperature at which ferrite and/or other low temperature phases in the strip is retransformed to austenite is such as to raise the temperature of the strip to more than 900°C.

11. A method as claimed in any one of the preceding claims in which the reheating of the strip to a temperature at which ferrite and/or other low temperature phases in the strip is retransformed to austenite is such as to raise the temperature of the strip to no more than 1100°C.

12. A method as claimed in any one of the preceding claims, wherein the recooling of the strip to retransform austenite in the strip to ferrite includes accelerated cooling of the strip while it is in line with the caster to a temperature less than 700°C.

13. A method as claimed in claim 12, wherein the strip is coiled after said accelerated cooling and brought to ambient temperature in the coiled condition.

14. A method as claimed in any one of the preceding claims in which the continuous caster is a twin roll caster comprising a pair of chilled casting rolls forming a nip between them, said casting pool of molten metal is

- 14 -

supported on the casting surfaces of the casting rolls immediately above the nip and the casting rolls are rotated to deliver said solidified strip downwardly from the nip.



1/11

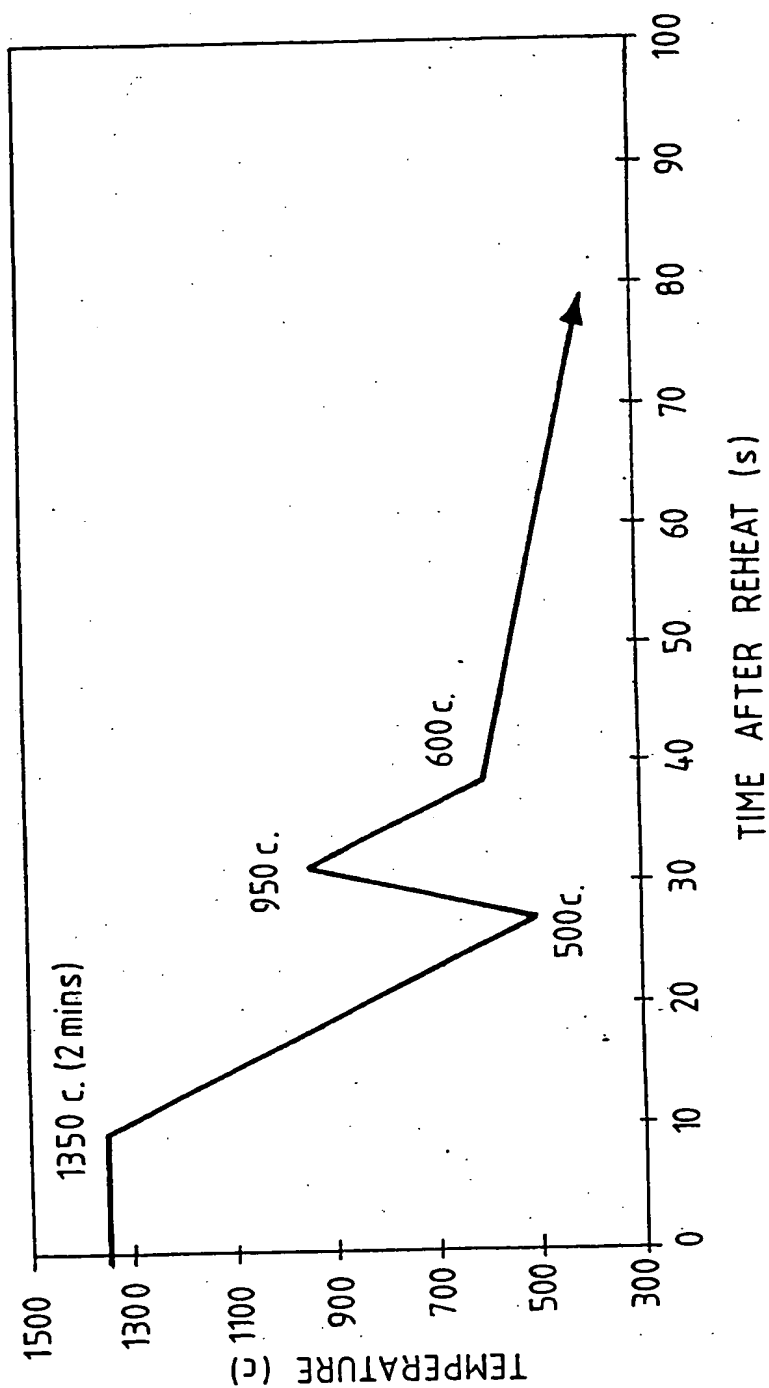
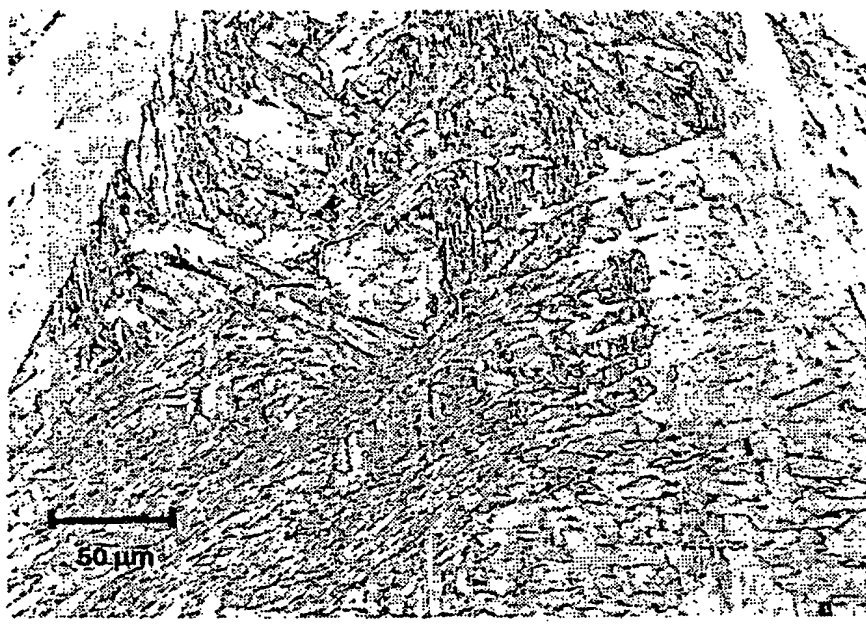


Fig. 1



III. 2.



III.3.

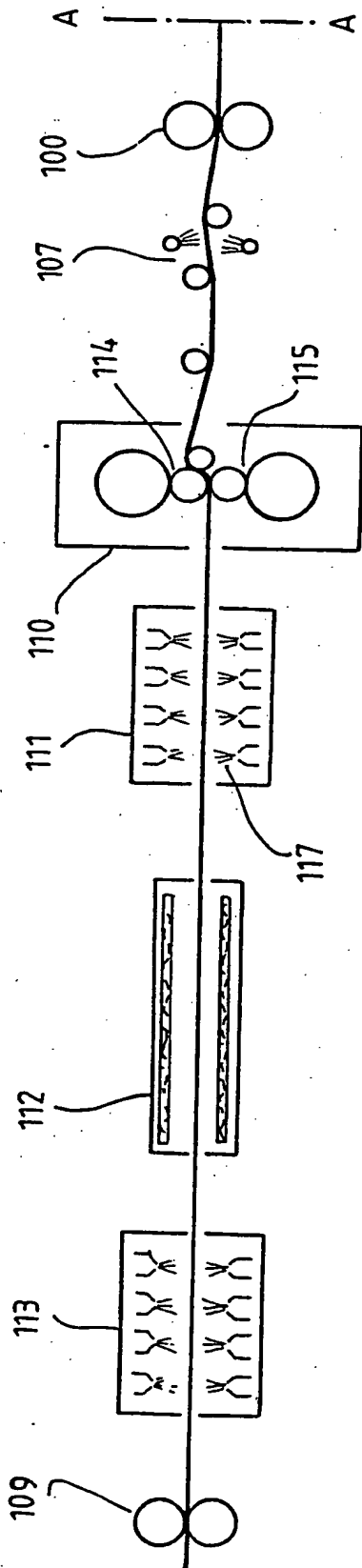


III. 4.



FIG. 5.

6/11

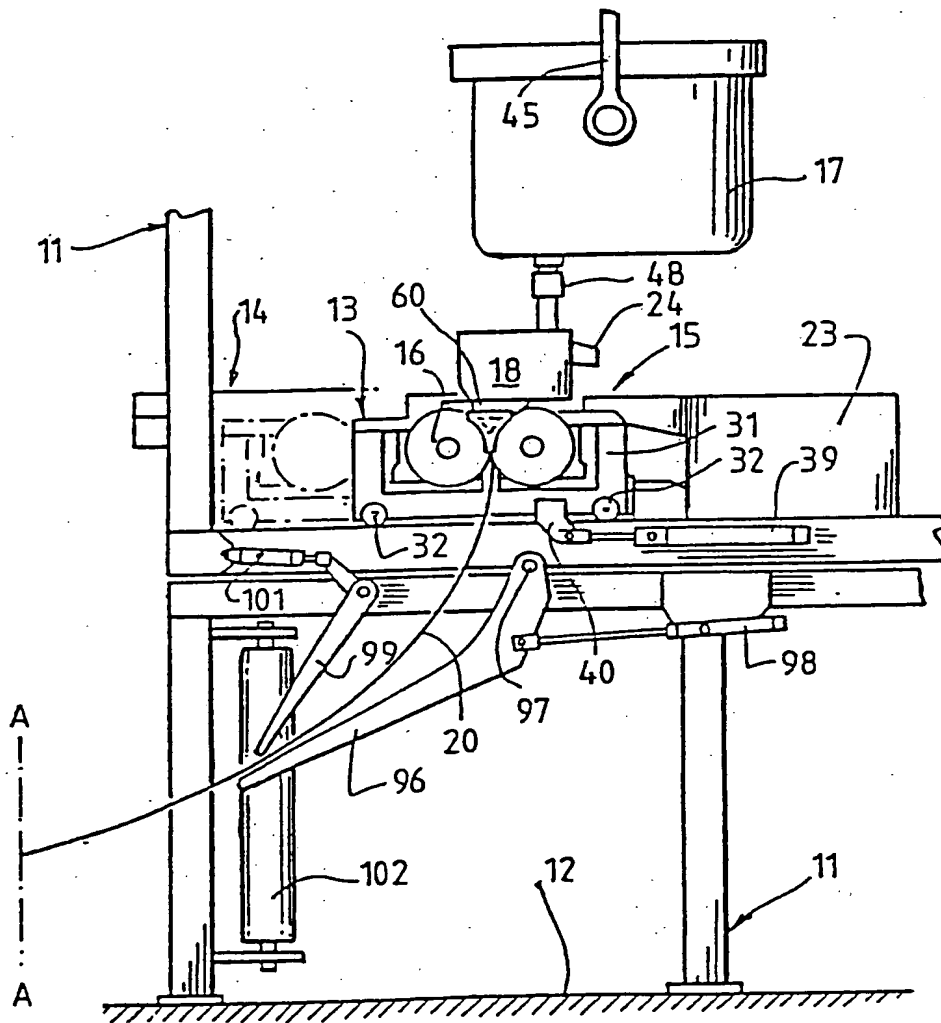


III 6.A

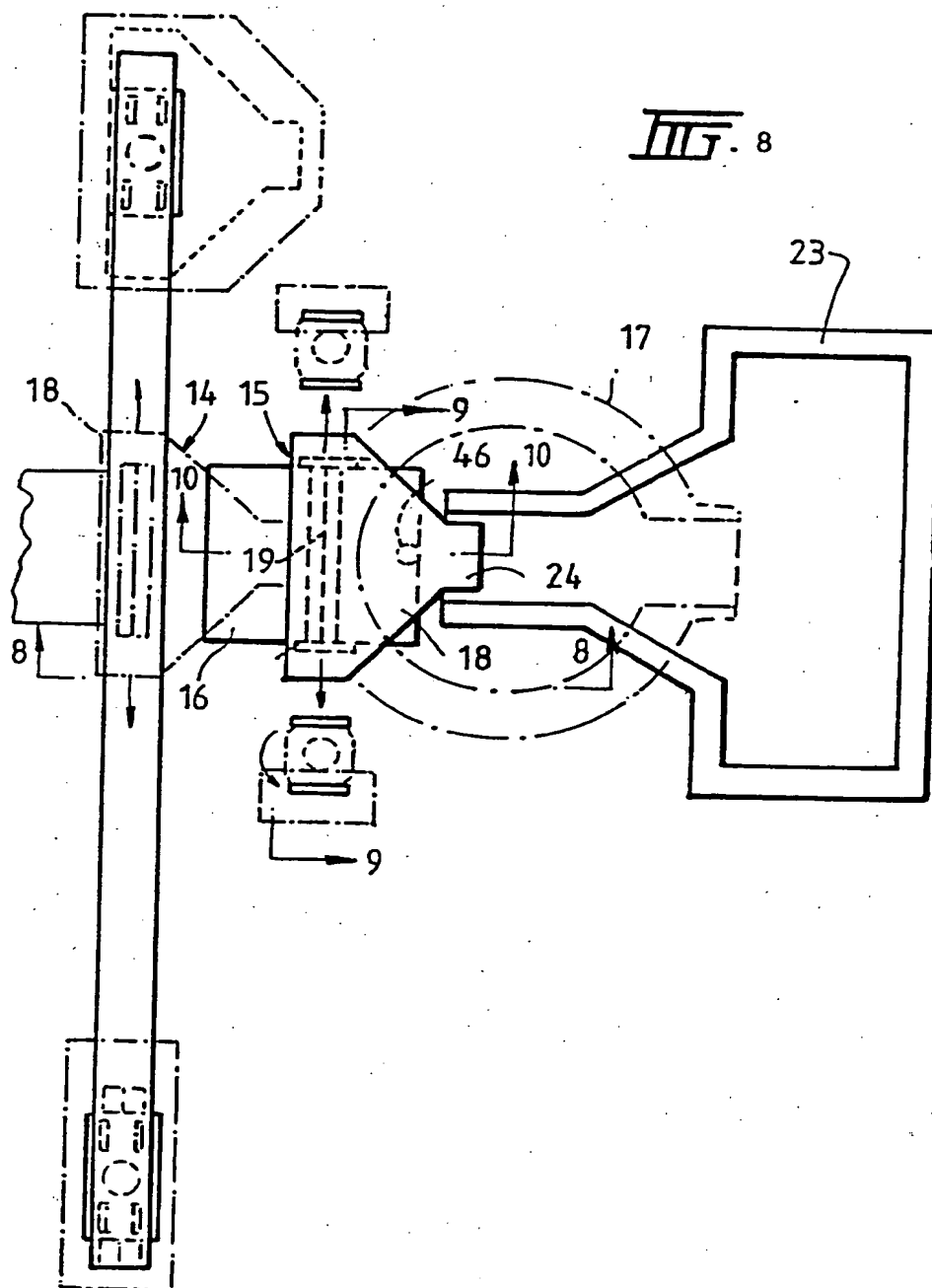
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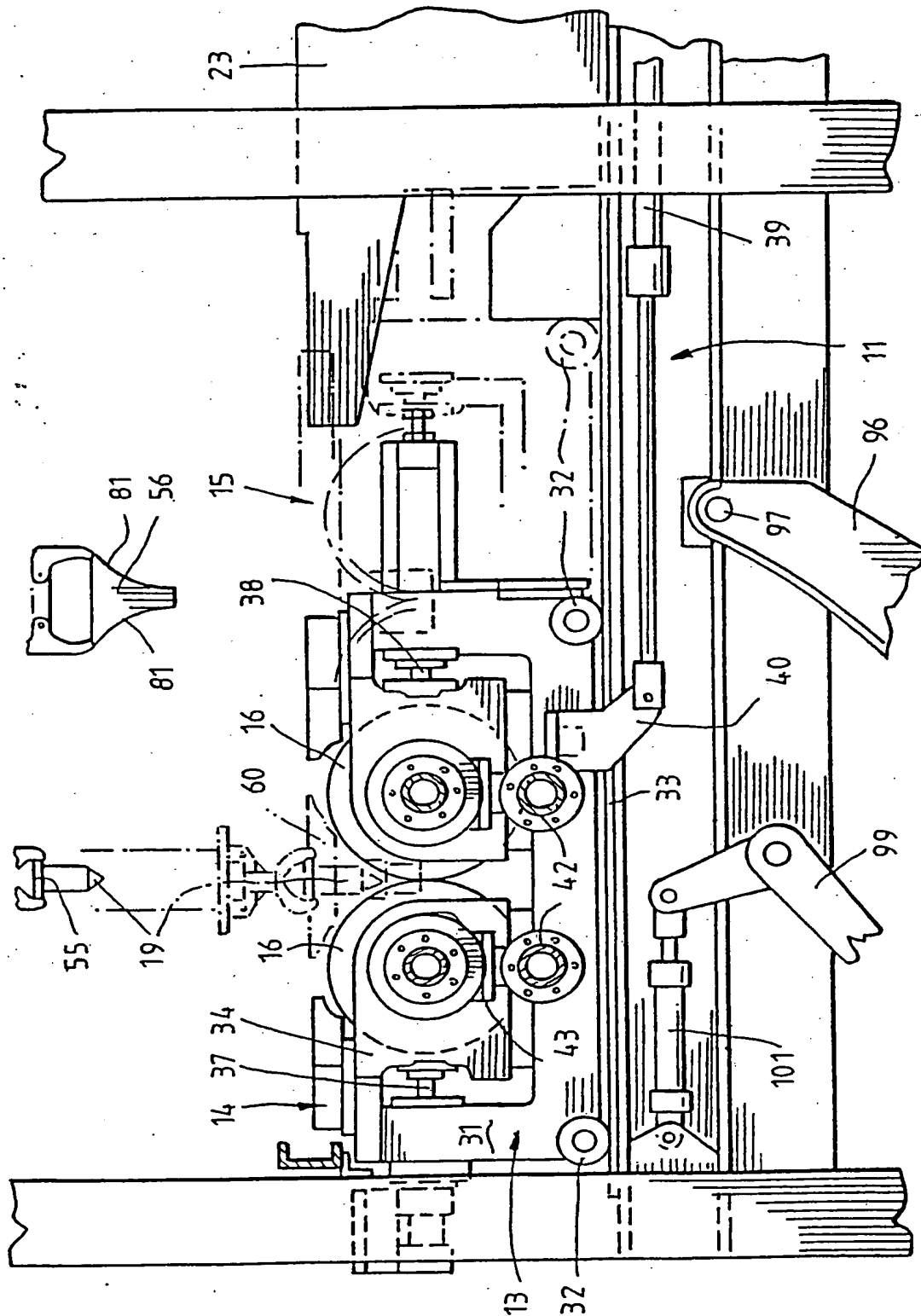
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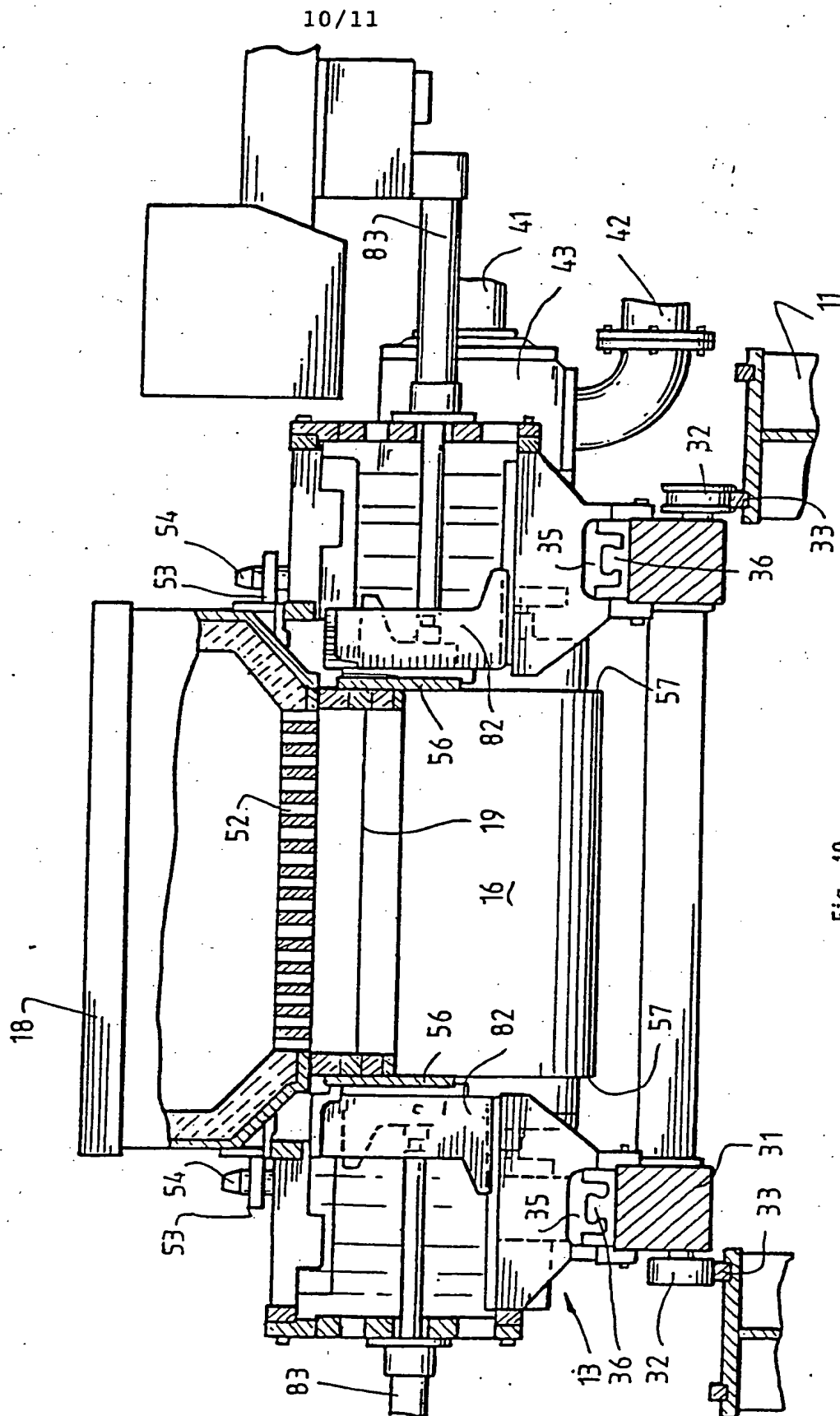




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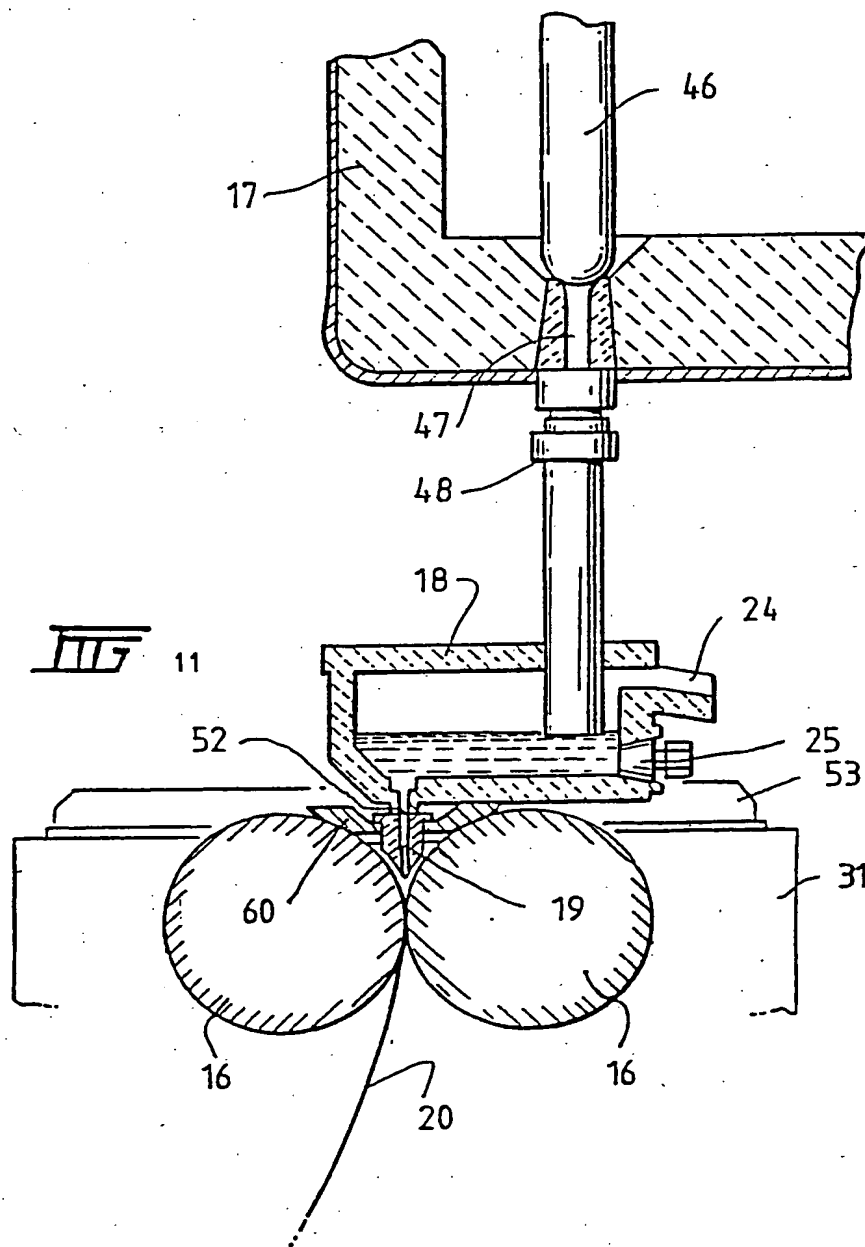
Fig. 9





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<b>A. CLASSIFICATION OF SUBJECT MATTER</b> Int. Cl. <sup>6</sup> B22D 11/12, 11/06, C21D 9/52, 8/02, 7/13.  According to International Patent Classification (IPC) or to both national classification and IPC					
<b>B. FIELDS SEARCHED</b>  Minimum documentation searched (classification system followed by classification symbols) IPC: B22D 11/12, 11/06, C21D 9/52, 8/02, 7/13, 7/14.  Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU: IPC as above.  Electronic data base consulted during the international search (name of data base, and where practicable, search terms used) DERWENT, JAPIO: STEEL: and (B22D 11/12, 11/06); AUSTENIT: and (C21D 9/52, 8/02, 7/13, (7/14 and STRIP:)).					
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>					
<b>Category*</b>	<b>Citation of document, with indication, where appropriate, of the relevant passages</b>	<b>Relevant to Claim No.</b>			
X	Patent Abstracts of Japan, C-907, page 39, JP, A, 3-249128 (NIPPON STEEL CORP) 7 November 1991 (07.11.91) abstract	1-9			
X	Patent Abstracts of Japan, C-907, page 39, JP, A, 3-249126 (NIPPON STEEL CORP) 7 November 1991 (07.11.91) abstract	1-9			
A	DD, A, 265641 (AKAD WISSENSCHAFT DDR) 8 March 1989 (08.03.89) abstract				
<div style="display: flex; justify-content: space-between;"> <div> <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.         </div> <div> <input checked="" type="checkbox"/> See patent family annex.         </div> </div>					
<table style="width: 100%; border: none;"> <tr> <td style="width: 33%; vertical-align: top;">           * Special categories of cited documents :             "A" document defining the general state of the art which is not considered to be of particular relevance            "E" earlier document but published on or after the international filing date            "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)            "O" document referring to an oral disclosure, use, exhibition or other means            "P" document published prior to the international filing date but later than the priority date claimed         </td> <td style="width: 33%; vertical-align: top;">           "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle of theory underlying the invention            "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone            "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art            "&amp;" document member of the same patent family         </td> <td style="width: 33%;"></td> </tr> </table>			* Special categories of cited documents :  "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle of theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
* Special categories of cited documents :  "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle of theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family				
Date of the actual completion of the international search 24 January 1995 (24.01.95)	Date of mailing of the international search report 7 Feb. 95 (07.02.95)				
Name and mailing address of the ISA/AU  AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA  Facsimile No. 06 2853929	Authorized officer  <div style="text-align: center;">   <b>VENKAT IYER</b>          Telephone No. (06) 2832144       </div>				

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
A	US,A, 4745786 (WAKAKO, et al.) 24 May 1988 (24.05.88) Figure 3; abstract.	
A	Patent Abstracts of Japan, C-209, page 47, JP,A, 58-193319 (NIHON STAINLESS K.K.) 11 November 1983 (11.11.83) abstract	
A	Derwent Abstract Accession No. 32806K/14, Class M24 (M27), JP,A, 58-31026 (SUMITOMO METAL IND KK) 23 February 1983 (23.02.83) abstract	

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member			
JP	3-249128	NONE				
JP	3-249126	NONE				
DD	265641	NONE				
US	4745786	CA	1264646	EP	227199	JP 62-89515
JP	58-193319	NONE				
JP	58-31026	NONE				
END OF ANNEX						